DOCUMENT RESUME

ED 290 636 SE 048 867

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TITLE New Development of Science and Technology in China.
PUB DATE 87
NOTE 15p.; Paper presented at the Annual Meeting of the Council of Graduate Schools (27th, Washington, DC, December 1-4, 1987).
PUB TYPE Reports - Descriptive (141) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *College Science; Developing Nations; *Foreign Countries; Institutional Research; Modernization; *Policy; Research; *Research and Development; *Science and Society; Science Education; *Technological Advancement
IDENTIFIERS *China

ABSTRACT

Since 1976 China has entered a new historical period in which the central task is to modernize agriculture, industry, national defense, and science and technology (S&T). The modernization of S&T is the key to the realization of the modernization in the other three fields. China has established a research and development (R&D) system of five component parts. The first part, the Chinese Academy of Sciences (CAS) focuses on research in basic sciences, newly emerging scientific areas and high technology. The second part, research institutions, mainly engage in applied research related to government. The third part, universities and colleges, concentrate on basic and applied sciences. The fourth part, research institutes for the national defense, concentrate on defense technology and the fifth part, provincial research institutes, makes up most of the S&T effort in China and are mainly concerned with applied research for local needs. This paper discusses the governing of China's R&D efforts, reforms of its managing system including funding, commercialization of technological achievements, encouragement of industry, personnel management and strengthening basic research. A strategy for developing science and technology is proposed. Seven priority research areas are identified including bio, space, information, laser, automation, energy and advanced materials technologies. (CW)

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NEW DEVELOPMENT OF SCIENCE AND TECHNOLOGY IN CHINA

LI MINGDE

China, which made many significant contributions to the world in science and technology in the past, is now facing a new situation and development. Since 1976 China has entered upon a new historical period in which the central task is to modernize agriculture, industry, national defence, and science and technology. The modernization of science and technology is key to the realization of the modernization in the other three fields. In 1980 the Chinese government, based upon the experience gained in the past 30 years, formulated a new policy guiding the progress of science and technology in China. The focus of this policy is that economic growth must rely on science and technology which in return must serve economic construction. Now the Chinese scientific and technical workers are doing their utmost to implement this general policy.

I. R&D System in China

For more than 38 years China has established a R&D system of five component parts with 4,690 R&D independent institutions and 576,000 S&T personnel of whom 231,000 are scientists and engineers. The total R&D expenditures directly appropriated by the government was 11 billion Chinese yuan in FY 1986.

The first part is the Chinese Academy of Sciences (CAS) with 122 research institutes and 58,220 S&T personnel accounting for about 10 percent of the S&T manpower in the country. Its efforts are focused on research in basic sciences, newly emerging scientific areas, and high technology.

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The second part is the research institutions that function under various mission agencies of the State Council. There are 622 research institutions under the mission agencies with 204,370 S&T personnel accounting for about 35 percent of the total S&T manpower. There are some outstanding research centers and academies in the mission agencies such as the Chinese Academy of Agricultural Sciences, the Chinese Academy of Forestry Sciences, the Chinese Academy of Medical Sciences, the Institute of Traditional Chinese Medicine, the Chinese Academy of Geological Sciences and so on. The research institutions under the mission agencies mainly engage in applied research and development closely related to the needs of various government agencies.

The third part is the research organizations that operate under the universities and colleges. In recent years many universities and colleges in China have established research institutes or laboratories of various kinds and their research areas consist of both basic and applied sciences.

The fourth part is the research institutions of national defence which concern themselves with newly developed techniques needed for defence.

The fifth part is the research institutions subordinate to provinces, autonomous regions and municipalities directly under the central government. There are altogether 3,946 institutes with 313,000 S&T personnel making up 54 percent of the total S&T manpower in the country. These institutes are mainly concerned with applied research and development directly related to their local needs.

The highest governing body for science and technology in China is the Science and Technology Steering Committee of the State Council. The State Science and Technology Commission (SSTC) is the government agency

responsible for implementation of science and technology policies, organization for attacking key problems of national importance, mastery of new technologies, review and sanction of inventions and for R&D budget allocation.

II. Reform of R&D Management System

The R&D management system in China is one that has been gradually formed over the past years and used to demonstrate rather powerful vitality in promoting the progress of science and technology in the country. However, with the new demand posed to science and technology by the reform of the economic system, and particularly with the challenge of the worldwide new technology advancement, the defects in our R&D management system were becoming more and more conspicuous. The main defects were: the state placed excessive control over the R&D activities and, as a result, the research institutions did not have sufficient autonomy; while practicing centrally planned management, we neglected the role of market mechanism and quite a few research institutions had no links at all with industry; the transfer from research results to production was rather difficult; and it was extremely hard for S&T personnel to move from one institution to another. Before the reform went into effect, about 83 percent of the S&T personnel at various research institutes depended entirely on government funds. The Chinese scientists and engineers are well-known for their diligence and dedication, but in the past, just because of the defects in R&D management system, their talent and wisdom have not been brought into fully play.

In order to solve all these problems, in March, 1985 the Chinese government issued the announcement of the Decision on the Reform of the R&D Management System. The present reform mainly concerns the following five aspects:

1. Reform of the funding system in support of research

The government will continue to fund the institutes doing research in such areas as medicine and health, labor protection, agricultural technologies, environmental protection as well as social services like astronomy, meteorology, standards and metrology, information, etc, but these institutes must accept the principle of block funding.

A part of basic research, some applied research and some big research projects will be supported through granting system, thus the National Natural Science Foundation of China (NSFC) was established accordingly in February, 1986. The Foundation selects the best proposals to support through peer review. The research and development of high tech with high risk will be financed directly by the government and some by venture capital. Research projects sponsored by the central and local governments will be funded under contract system. The block funding for research institutes engaged in technology development will be gradually reduced year by year and, hopefully in about five years or more, these institutes will be self-supported by engaging in contract research, providing services and technology transfer.

2. Commercialization of technological achievements

In the past, technological achievements were not transacted like commodities in the marketplace in China for they were not regarded as commodities. So for a long time technological achievements were transfered free of charge in China. Now China has created a technology market to commercialize technology achievements so as to ensure a continuous technology flow from research institutions to industry, to agriculture and to the entire society.

3. Encouraging the industry to absorb and develop technology

In China the industries have been very weak in absorbing and

developing technology. With the current reform underway, the government is, on the one hand, giving the industries more and more autonomy, and on the other, encourages the industries to enter into partnerships of various kinds with universities and colleges and research institutes. The enterprises and particularly the large ones are asked to set up their own institutions for R&D activities, and the medium and small ones are encouraged to jointly set up R&D institutions or to seek support from research institutes and universities and colleges. Now more and more research institutions and universities and colleges have entered into long-term or permanent collaborative relationships with industries, and some institutes have been even merged into large enterprises or enterprise groups.

4. Reform of S&T personnel management

In S&T personnel management, China will gradually adopt a retainer system; in the management of research institutions, a system of responsibility to the director of the institute will be introduced; rational mobility of S&T personnel should be allowed and the scientists and engineers are encouraged to go and work in the countryside, in the medium and small firms, and in the remote and less developed regions.

5. Strengthening basic research

In order to have a strong base for the development of science and technology, China will continue to strengthen its basic research. The government will increase its spending for basic research and will improve facilities, instrumentation and other conditions for scientific research. The S&T personnel for basic research will be also adjusted and reinforced accordingly.

Quite a number of post-doctoral stations have been established in some research institutes of CAS and other agencies and some universities in China. In so doing, basic research can be strengthened, and at the same

time, highly qualified S&T personnel can be replenished. The post-doctoral stations are focused on basic research and the scientists working in the stations are mainly those who have received their Ph.Ds recently from abroad.

The reform is going on satisfactorily, but there are still many things remaining to be done, for instance, the drawing up of the specific regulations for implementing the policies set forth in Decision on the Reform of the R&D Management System, the reinforcement of science and technology legislation, etc. So further efforts are needed in these respects so as to make science and technology better serve the interests of the country and the people.

III. Strategy for the Development of Science and Technology

The general strategic goal in China is to quadruple its 1980 industrial and agricultural output by the year 2000, with a preliminary foundation laid during the first decade (1981-1990) to achieve a more rapid and equitable growth during the next decade.

Guided by this general goal, China's strategy for the development of science and technology places strong stress on the application of proven technologies to raise the technical level of production sectors. Its general objective is to popularize in the main, by the end of this century, those advanced production technologies which were widely used in economically developed countries in late 1970's or early 1980's and are applicable in China; at the same time, efforts should be made selectively in certain high-tech and basic research areas so as to catch up with the world advanced level. Therefore, the national endeavors in science and technology will fall into the four parts:

1. Transformation of traditional industries by adopting new technologies

In present Chinese industrial structure, the output value from the traditional industries accounts for about 95 percent of the gross output value of industry. For a long time to come, the traditional industries will continue to be the prime mover of the Chinese economy. To reach the strategic goal of quadrupling the 1980 gross output value by the year 2000, China will primarily depend on traditional industries. Therefore, the technological level of the traditional industries and their production capacity constitute the lifeline of the Chinese economy. At the moment, the technology in the traditional industries is still very backward and the labor productivity in China is also pretty low. The industries that have reached the world advanced standard of the 70's and 80's in terms of quality and performance only account for about 15 percent, while the technological level of the remaining 85 percent still remains that of the 50's and 60's, and even 40's in some cases.

In the period from 1986 to 1990, 50 percent of the funds for state capital construction will be invested in the technical transformation of the traditional industries. Hence, one of the most important tasks of the S&T endeavors in China at present is to serve this technical transformation by facilitating technology development, introducing foreign advanced technologies, and providing better equipment for the traditional industries.

In order to save time, the introduction of foreign advanced technologies is of special importance. From 1981 to 1986, more than 3,100 technological items were imported with the cost of 2.9 billion U.S. dollars. most of those technologies have played and are playing an important role in production. For the period from 1986 to 1990, the expenses for

technology imports will be doubled in order to introduce more advanced technologies needed for the development of industry and agriculture.

2. The Spark Program serving the development of rural industries

The rural areas, the home of 80 percent of the Chinese population, have been in the backward state of natural economy in history. Without putting an end to this backwardness, the modernization of the entire nation will be out of question. Recently, thanks to the restructuring of the rural economic management system and reinvigoration of the urban economy, the township enterprises have been set up across the vast areas of the countryside and have played an important role in changing the structure of China's employment picture and the relationship between rural and urban areas. China had a labor force of 350 million engaged in agriculture. Now 80 million of them have been moved to manufacturing and tertiary industries in rural areas, the output of which in 1986 totalled 354 billion yuan, about 19 percent of the country's total output value. At the present momentum, the annual output value is expected to reach 1 trillion yuan by the year 2000 or one third of the gross output value of industry and agriculture at the time, and these rural enterprises will be employing a total of more than 150 million people, which accounts for roughly one third of the rural labor force.

Nevertheless, the problems generally found in today's rural and township enterprises are backward technology, serious shortages of technical manpower and advanced equipment, and environmental pollution. In order to address these problems and enable those rural enterprises to develop soundly, the government has drawn up a special plan titled Spark Program. The principal goal of the program is to start a number of "short, simple

and appropriate, and quick" technological projects for the rural development. "Short" means short cycle needed for technology development; "simple and appropriate" means that the technology to be adopted should be suitable for the present economic development and management in the countryside; and "quick" means that the projects should be able to bring about quick economic returns. By depending on this type of technology, a large number of rural and township enterprises and all professions and trades in the countryside will move step by step towards specialization and modernization.

The Spark Program has drawn enthusiastic support from all the local governments and various central government agencies. Among the 4,000 projects with 2 billion yuan investment in 1986, 70 percent gained good results at the end of the year. Now the Chinese government has decided to make the Spark Program a main and long-term policy for invigorating the rural economy and one of the strategies for the development of science and technology in the country.

3. High Technology Development Program

For a long-term point of view, to revitalize the Chinese economy invariably hinges on high technology, thus the High Technology Development Program was initiated in 1986. As an immediate part of the strategic objectives within this century, China's high technology research and development constitute a component of the Seventh Five Year Plan (1986-1990). The projects outlined in the program aim at pooling together the best technological resources in China over the next 15 years to keep up with international high technology development, bridge the gap between China and other countries in several most important areas, and wherever possible strive for breakthroughs. The program also aims at providing technological backup for economic development and train large numbers of talents for the future.

There are seven priority research areas included in this program. Since China is at present not in a position to finance a comprehensive program, not even all branches within the seven areas, arrangements have been made on the basis of the country's actual capabilities and to give prominence to priorities.

Biotechnology

The objective is to improve people's health through better nutrition by early next century. The following areas are included:

High-yield, high quality and adversity-proof animals and plants

New medicines, vaccines and genic therapy and

Protein engineering

Space Technology

Advanced launch vehicles with enhanced capacity will be developed to meet the growing demands for commercial launch services. R&D activities will continue on space science and technology for peaceful purposes.

Information Technology

Emphasis will be focused on technologies promising significant breakthroughs and extensive application at the beginning of the next century. The following areas are included:

Intelligent computer systems

Optoelectronic devices and microelectronic/optoelectronic systems integration technology and

Information acquisition and processing technology

Laser Technology

R&D will be carried out in laser technologies to achieve better quality and performance. Laboratory achievements will be applied to material processing, plasma technology, pulse power technology, high

resolution spectroscopy, etc.

Automation Technology

It includes the following two areas:

Computer integrated manufacturing system and

Intelligent robots

Energy Technology

It also includes two areas:

Coal-fired MHD power generation technology and

Advanced nuclear reactor technology

Advanced Materials

The major items included are:

Photo-electronic materials

High-performance structural materials with corrosion resistance and light weight

Special functional materials

High temperature-wear resistance and high strength composite materials and research on special testing and measuring techniques

4. Support to basic and applied research

Basic research is of far-reaching significance to the advancement of science and technology and to the social and economic development. Major breakthroughs in the field of basic research tend to result in major changes in technology. So China must have its own basic research capabilities. But given the limited funds available for S&T endeavors, China will not be able to exert an overall effort in every aspect of basic and applied research and the general guideline in supporting basic and applied research is the following:

- those research that will have long-term effect on future development

of China's national economy and society;

- The research that may contribute to the exploitation and utilization of China's abundant natural resources;

- Those areas where China possesses a relatively strong capability and is possible to get a breakthrough; or

- Those research that will contribute to the enhancement of China's major scientific reserve.

At present, an ad-hoc task force has been organized to make in-depth study of the status of basic research in China in order to evaluate the effect of the reform of R&D management system and to propose policy options.

Along with the development of the national economy, government appropriations for science and technology will increase annually. In addition, with the reduction of direct support to technology development, China will, in such forms as grants and awards, increase allocations for important basic and applied research. Meanwhile, the government will remould and build a number of laboratories and improve the conditions of basic and applied research.

So the strategic deployment of China's scientific and technological activities comprises efforts at three levels. The efforts at the first level are directly concerned with serving the economic construction, where it is hoped to deploy 70-80 percent of the S&T manpower. Efforts at this level will be focused on some major national R&D projects that have a vital role to play in the country's industrial and agricultural production. The efforts at the second level are designed to

develop high technology which is key to ensuring the future development of science and technology in China. The efforts at the third level are primarily aimed at strong support to basic and applied research in selected areas that have profound impact on the economic growth and the enhancement of knowledge. So it can been seen that the strategy for the development of science and technology in China is in conformity with the Chinese specific conditions and has taken account of both long-range goals and short-term objectives.

IV. Scientific Exchanges with Other Countries

In accordance with the policy of opening to the outside world,China is also actively carrying out scientific and technical exchanges and cooperation with other countries. By the end of 1986, China has established relationships of scientific and technical exchanges and cooperation with 106 countries and regions and has signed official agreements for scientific cooperation with 50 countries. The Chinese specialized societies have also joined 250 international scientific and technical organizations. The annual number of S&T people coming to China and going abroad totaled about 40,000 in 1986. With such large-scale exchange programs, it is hoped that the Chinese scientists and engineers could join hands with their colleagues of other countries in further hightening the level of international activities for the advancement of science and technology.

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